Final Preliminary Project Report
For Stakeholder Review

Total Maximum Daily Loads for Fecal Coliform in Santa Maria River and Oso Flaco Creek watersheds, Santa Barbara County, California

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LIST OF ACRONYMS AND ABBREVIATIONS

CCAMP	Central Coast Ambient Monitoring Program
E. coli	*Escherichia coli bacteria*
GIS	Geographic Information System
MEP	maximum extent practicable
MPN	Most Probable Number
MRLC	Multi-Resolution Land Characterization
MS4s	Municipal Separate Storm Sewer Systems
NPDES	National Pollutant Discharge Elimination System
QAPP	Quality Assurance Project Plan
REC-1	Water contact recreation
REC-2	Non-water contact recreation
SSO	Site-specific objective
TMDL	Total Maximum Daily Load
UAA	Use Attainability Analysis
USGS	United States Geologic Survey
Water Board	Regional Water Quality Control Board (Region 3)
WDR	Waste Discharge Requirements
WWTP	Waste Water Treatment Plant

1. PROJECT DEFINITION

This report addresses the impairment of Oso Flaco Creek and its tributary, Little Oso Flaco Creek, and the Santa Maria River and several of its tributaries and drainages (Alamo Creek, Blosser Channel, Bradley Canyon Creek, Bradley Channel, Nipomo Creek, and Orcutt-Solomon Creek). Each of these water bodies, with the exception of Little Oso Flaco Creek, is specifically identified on the 303(d) list for fecal coliform.

This report was prepared in the context of numerous existing efforts occurring on multiple land uses and regulatory mechanisms aimed at reducing bacterial loading. As part of this report, staff identified possible implementation actions, or alternatives that will further address controllable bacterial sources.

The information contained in this report will be used as the foundation for development of a Draft Project Report to be completed in January 2007.

2. WATERSHED DESCRIPTION

The Santa Maria and Oso Flaco watersheds are located within Santa Barbara and San Luis Obispo Counties, California. The watersheds are located on the central coast of California about 50 miles north of Point Conception and about 150 miles south of Monterey Bay. The climate is mild with an average rainfall of 14 inches a year.

Staff concluded that the primary land uses were rangeland, irrigated agriculture, and urban lands. Figure 1 and Figure 2 show the locations of the watersheds and major water bodies. Little Oso Flaco Creek (not shown in Figure 2) drains to Oso Flaco Creek from the east. Blosser and Bradley Channels and Bradley Canyon Creek (also not shown in Figure 2) flow into the Santa Maria River from the south.

Figure 1. CCAMP monitoring locations in the upper Santa Maria watershed.

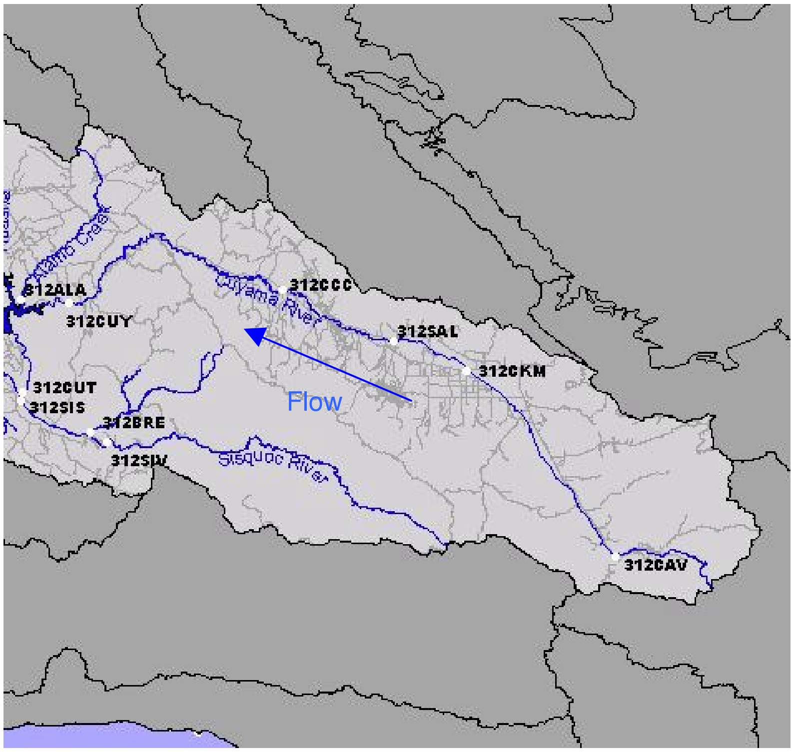
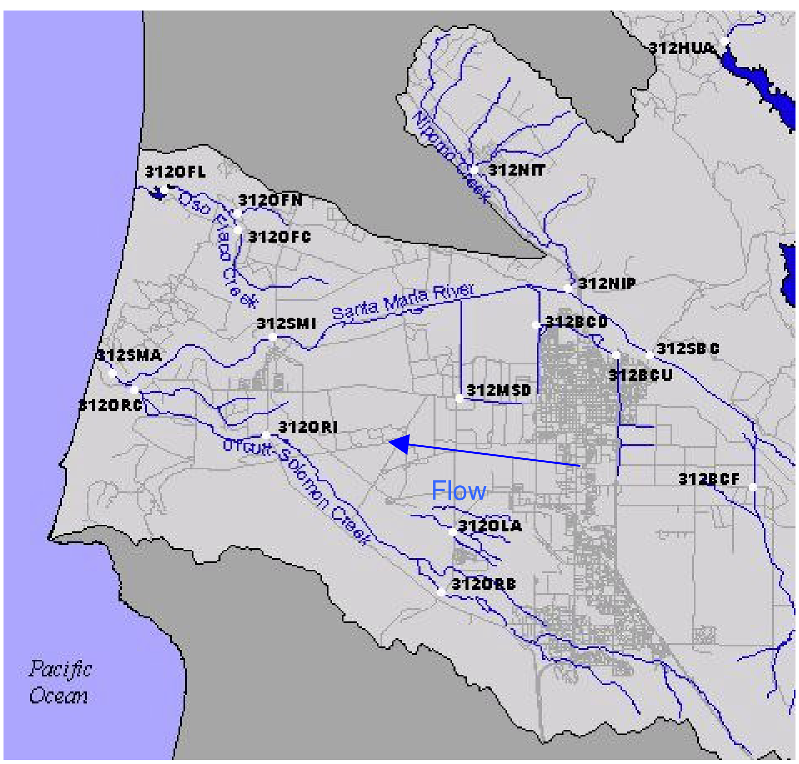


Figure 2. CCAMP monitoring locations in the lower Santa Maria watershed and Oso Flaco watershed.



2.1. Beneficial Uses

The Central Coast Regional Water Quality Control Board (Water Board) is responsible for protecting water resources from pollution and nuisance that may occur as a result of waste discharges. The Water Board determines beneficial uses (in the *Water Quality Control Plan* (Basin Plan) that need protection and adopts water quality objectives that are necessary to protect the beneficial water uses in the Basin Plan.

The beneficial uses associated with human health are the principal water quality consideration with respect to fecal coliform. Bacterial indicator organisms, e.g., fecal coliform and *E. coli*, are commonly used for predicting the presence of pathogenic organisms. If a concentration threshold of indicator bacteria is detected in a sample, pathogenic organisms may also be present. Elevated levels of fecal coliform are indication that the water bodies may be unsafe for swimming, fishing or other forms of water contact and non-contact (REC-1 and REC-2) activities.

The Basin Plan specifically identifies beneficial uses for some of the listed water bodies included in this analysis. The Santa Maria River, Alamo Creek, Orcutt Creek, and Oso Flaco Creek have designated beneficial uses in the Basin Plan. The beneficial uses cited in the Basin Plan are listed in Table 1. Staff interprets Orcutt Creek as being synonymous with Orcutt-Solomon Creek. This report does not address the Santa Maria River Estuary and it's designated shellfish harvesting beneficial use.

The Basin Plan also states that surface water bodies within the region that do not have beneficial uses specifically designated for them are assigned the beneficial uses of "municipal and domestic water supply" and "protection of both recreation and aquatic life." Staff interpreted this general statement of beneficial uses to encompass REC-1, REC-2, MUN, and WARM. Blosser Channel, Bradley Canyon Creek, Bradley Channel, Nipomo Creek, and Little Oso Flaco Creek were not specifically listed in the Basin Plan and therefore were designated with those beneficial uses.

Table 1. Beneficial uses for Oso Flaco Creek, Santa Maria River, Orcutt Creek, and Alamo Creek.

Water body	Oso Flaco Creek	Santa Maria River	Orcutt Creek	Alamo Creek
Municipal and Domestic Supply (MUN)	X	X	X	X
Agricultural Supply (AGR)	X	X	X	X
Industrial Service Supply (IND)		X		
Ground Water Recharge (GWR)	X	X	X	X
Water Contact Recreation (REC-1)	X	X	X	X
Non-Contact Water Recreation (REC-2)	X	X	X	X
Wildlife Habitat (WILD)	X	X	X	X
Cold Fresh Water Habitat (COLD)		X	X	X

Warm Fresh Water Habitat (WARM)	X	X		X
Migration of Aquatic Organisms (MIGR)		X		
Spawning, Reproduction, and/or Early Development (SPWN)				X
Preservation of Biological Habitats of Special Significance (BIOL)	X			
Rare, Threatened, or Endangered Species (RARE)	X	X	X	X
Estuarine Habitat (EST)			X	
Freshwater Replenishment (FRSH)	X	X	X	
Commercial and Sport Fishing (COMM)	X	X	X	X

2.2. Problem Statement

Oso Flaco Creek, the Santa Maria River and listed tributaries and drainages are on the 2002 Clean Water Act (CWA) Section 303(d) List of Water Quality Limited Segments (the 303(d) list) because bacteria levels exceeded the fecal coliform water quality objective for water contact recreation. Water Board staff previously used water quality data collected by the Central Coast Ambient Monitoring Program (CCAMP) to recommend inclusion on the 303(d) list. The results of CCAMP data collection, along with additional data collected in these watersheds are discussed in Section 4 *Data Analysis*.

3. NUMERIC TARGET

The most stringent water quality objective for fecal coliform applies to the water contact recreation (REC-1) beneficial use. The Basin Plan contains the following REC-1 bacteria objective for inland surface waters, enclosed bays and estuaries:

> "Fecal coliform concentration, based on a minimum of not less than five samples for any 30-day period, shall not exceed a log mean of 200/100 mL, nor shall more than ten percent of total samples during any 30-day period exceed 400/100 mL."

Often, available datasets do not contain five samples in a 30-day period, so the portion of the objective that is evaluated is that "no more than ten percent of total samples during any 30-day period exceed 400/100 mL." In instances where fewer than five samples were collected in 30 days, the "ten percent" threshold is exceeded if any one sample exceeds 400/100 mL.

Although the Central Coast Region's Basin Plan does not have water quality objectives for *E. coli*, the Colorado River Region's Basin Plan includes a water quality objective for *E. coli*-based on a minimum of not less than five samples for any 30-day period, concentrations shall not exceed a log mean of 126 MPN/100 mL nor shall any sample exceed 400 MPN/100mL.

The US Environmental Protection Agency recommends the following *E. coli* levels in their bacterial indicator criteria recommendations:

Indicator	Risk Level	Geometric Mean Density (per 100 mL)	Single Sample Maximum Allowable Density (per 100 mL)[a]			
			Designated Beach Area (75th percentile)	Moderate Full Body Contact Recreation (82nd percentile)	Lightly Used Full Body Contact Recreation (90th percentile)	Infrequently Used Full Body Contact Recreation (95th percentile)
E. coli	8	126[b]	235	298	409	575

Source: U.S. EPA (1986).
a. Calculated using the following: single sample maximum = geometric mean * 10^(confidence level factor * log standard deviation), where the confidence level factor is: 75%: 0.675; 82%: 0.935; 90%: 1.28; 95%: 1.65. The log standard deviation from EPA's epidemiological studies is 0.4 for fresh waters.
b. Calculated to nearest whole number using equation: geometric mean = antilog_{10} [(risk level + 11.74) / 9.40].

Staff used the single sample values of 235MPN/100mL and 400MPN/100mL to evaluate *E. coli* data, and the water quality objective of 400MPN/100mL to evaluate fecal coliform data presented in Section 4 *Data Analysis*.

The proposed fecal coliform targets for this project as identified in Table 2 are consistent with the water quality objectives in the Basin Plan for fecal coliform. Staff is also proposing *E. coli* targets consistent with bacterial indicator criteria recommendations as identified in Table 2.

Table 2. Numeric Targets for Oso Flaco Creek and Little Oso Flaco Creek and Santa Maria River and tributaries.

Fecal Coliform [a]	
Log Mean	Maximum
200 MPN/100 mL [b]	400 MPN/100 mL [c]
E. coli [d]	
Log Mean	Maximum
126 Mean density/100 mL [e]	235 Maximum density /100 mL [f]

a: Source - Regional Water Quality Control Board, Basin Plan 1994.
b Log mean of no less than five samples over a period of 30 days.
c: No more than 10% of total samples during a period of 30 days exceed.
d: Source – U.S. EPA's 1986 bacterial indicator criteria recommendation.
e: Calculated to nearest whole number using equation: geometric mean = antilog_{10} [(risk level + 11.74) / 9.40].
f: Calculated using the following: single sample maximum = geometric mean * 10^(confidence level factor * log standard deviation), where the confidence level factor is: 75%: 0.68; 82%: 0.94; 90%: 1.28; 95%: 1.65. The log standard deviation from EPA's epidemiological studies is 0.4 for fresh waters.

4. Data Analysis

4.1. Background on fecal indicator bacteria

Ambient water quality assessments for fecal coliform rely principally on analysis of total and fecal coliform bacteria in grab samples. The total coliform group of bacteria is from the family, *Enterobacteriaceae*, which includes over 40 genera of bacteria. Bacteria of both fecal and non-fecal origin are included in the total coliform group. Common habitats for the group include soil, groundwater, surface water, the intestinal tract of animals and humans, the surface of plants, algal-mats in pristine streams, wastes from the wood industry, and biofilms within drinking water distribution systems (Hurst, et al., 2002). The total coliforms can be divided into various groups based on common characteristics. Among these, the fecal coliforms are generally indicative of fecal sources, though not all members of the group are of fecal origin (Hager, et al, 2004, p. 6). The bacteria species, *Escherichia coli (E. coli)*, comprises a large percentage of coliform detected in human and animal feces. Some strains of *E. coli* are pathogenic (e.g. the O157:H7 species) and some are not.

Analysis of water samples to detect the presence of fecal coliform and/or *E. coli* is one way to determine the potential presence of pathogens. However, analytical methods for quantifying bacteria lack the precision common to many laboratory methods for water quality analysis. For example, the Multiple Tube Fermentation[1] method results in an estimate of the most probable number (MPN) of bacteria. This number varies considerably and for a given result of 1,600 MPN/100mL for example, the 95% confidence limit ranges from 600 to 5,300 MPN/100mL. The other common method, Membrane Filtration, also has limitations, such as potentially under representing the concentration of coliform, particularly with highly turbid samples. In spite of these analytical limitations, testing for fecal coliform and/or *E. coli* is one of the best available methods to indicate potential fecal contamination (Hager, p. 7).

There are various methods available to differentiate sources of fecal waste. While all methods have demonstrated drawbacks, are under development, and no method is more than experimental in nature, genetic methods of microbial source tracking are among the most definitive ways available to determine relative contribution of specific animal sources of *E. coli.* Water Board staff has successfully used genetic data in multiple watersheds to determine sources, and identify and prioritize implementation actions. These methods however, are expensive and time-consuming, especially if multiple water bodies are in question. Furthermore, in watersheds where there is a mosaic of land uses, conducting a microbial source tracking study may not provide definitive source identification because different animal sources can originate from multiple land uses. Moreover, determining relative contributions determined by genetic methods may not change the approach to solving the problem.

The levels of fecal coliform and *E. coli* detected during this study indicated that the Santa Maria and Oso Flaco watersheds have a bacterial problem throughout most of their system. The following discussion addresses where and to what degree the problem occurs, along with a review of microbial source tracking results from assessments in other watersheds that may be transferable to the Santa Maria and Oso Flaco watersheds. A subsequent section, *Source Analysis*, describes the results of sampling and analysis aimed at tracking the source of the problem.

[1] when referring to Multiple Tube Fermentation, staff is including both the conventional multiple tube method and IDEXX's colilert trays.

4.2. Data and Information Evaluated

Staff relied on data collected by the following entities or programs in preparing this report:

- Central Coast Ambient Monitoring Program (CCAMP),
- Water Board TMDL Program,
- City of Santa Maria,
- County of Santa Barbara's Project Clearwater,
- Morro Bay National Monitoring Program,
- Geographic Information System analysis of land uses, and
- Genetic studies.

The following discussion summarizes the monitoring activities and results from these efforts.

4.3. Water Quality Data

a. Central Coast Ambient Monitoring Program

The Water Board's Central Coast Ambient Monitoring Program (CCAMP) staff conducted monthly monitoring in 2000 and 2001. Monthly water quality monitoring continued at the Santa Maria River site at Rancho Guadalupe Dunes Preserve through August 2003. Figure 1 and Figure 2 show the locations of the water bodies and sampling sites. Table 3 shows the names of the sampling sites. Figure 3 shows the log (geometric) mean and range of data collected at each site in the Santa Maria hydrologic unit area, along with the water quality objective of 400 MPN/100mL. Sites are displayed in order of decreasing log mean. Percent exceedances and special representation of data are shown in Table 4.

Table 3. CCAMP monitoring locations in the Santa Maria and Oso Flaco watersheds

Water body	site name	site location
Alamo Creek	312ALA	312ALA-Alamo Creek at Alamo Creek Road
Blosser Channel	312BCD	312BCD-Blosser Channel d/s of groundwater recharge ponds
Bradley Canyon Creek	312BCF	312BCF-Bradley Canyon diversion channel @ Foxen Canyon Road
Bradley Channel	312BCU	312BCU-Bradley Channel u/s of ponds @ Magellan Drive
LaBrea Creek	312BRE	312BRE-LaBrea Creek u/s Sisquoc River
Cuyama River(above res.)	312CAV	312CAV-Cuyama River @ Highway 33
Cuyama River(above res.)	312CCC	312CCC-Cuyama River d/s Cottonwood Canyon
Cuyama River(above res.)	312CUL	312CUL-Cuyama River above Lockwood turnoff
Cuyama River(below res.)	312CUT	312CUT-Cuyama River below Twitchell @ White Rock Lane
Cuyama River(above res.)	312CUY	312CUY-Cuyama River d/s Buckhorn Road
Huasna River	312HUA	312HUA-Husana River @ Huasna Townsite Road
Main Street Canal	312MSD	312MSD-Main Street Canal u/s Ray Road @ Highway 166
Nipomo Creek	312NIP	312NIP-Nipomo Creek @ Highway 166
Nipomo Creek	312NIT	312NIT-Nipomo Creek @ Tefft Street
Oso Flaco Creek	312OFC	312OFC-Oso Flaco Creek @ Oso Flaco Lake Road
Oso Flaco Lake	312OFL	312OFL-Oso Flaco Lake @ culvert

Little Oso Flaco Creek	312OFN	312OFN-Little Oso Flaco Creek
Betteravia Lakes	312OLA	312OLA-Betteravia Lakes at Black Road
Orcutt Solomon Creek	312ORB	312ORB-Orcutt Solomon Creek @ Black Road
Orcutt Solomon Creek	312ORC	312ORC-Orcutt Solomon Creek u/s Santa Maria River
Orcutt Solomon Creek	312ORI	312ORI-Orcutt Solomon Creek @ Highway 1
Salisbury Creek	312SAL	312SAL-Salisbury Creek @ Branch Canyon Wash
Santa Maria River	312SBC	312SBC-Santa Maria River @ Bull Canyon Road
Sisquoc River	312SIS	312SIS-Sisquoc River @ Santa Maria Way
Sisquoc River	312SIV	312SIV-Sisquoc River u/s Tepusquet Road
Santa Maria River	312SMA	312SMA-Santa Maria River @ Rancho Guadalupe Dunes Preserve
Santa Maria River	312SMI	312SMI-Santa Maria River @ Highway 1

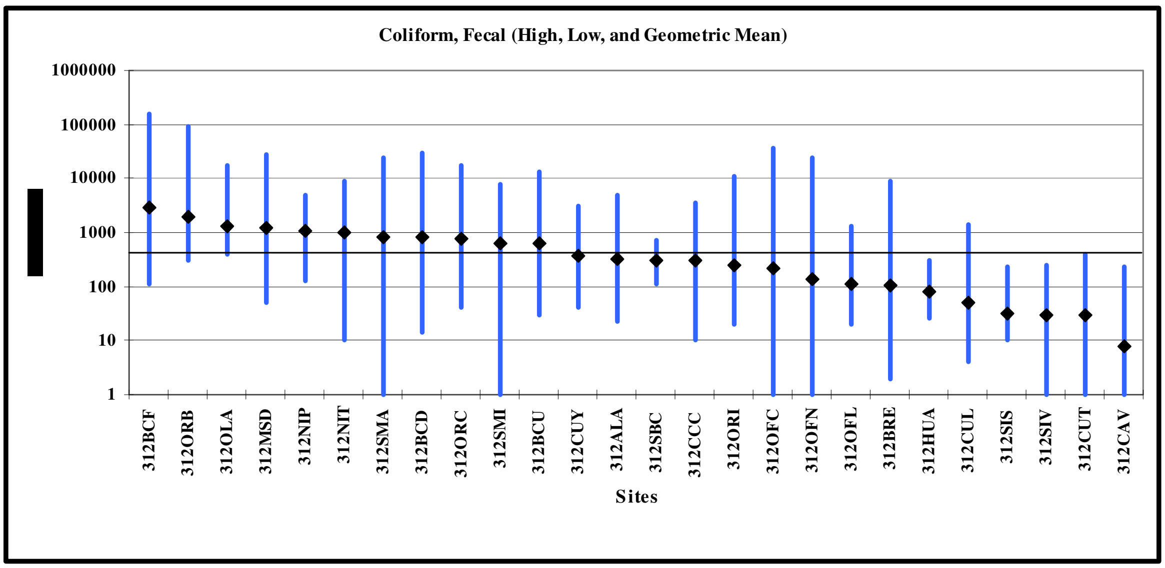


Figure 3. CCAMP monitoring data in the Santa Maria and Oso Flaco watersheds.

Table 4. Percent exceedances and water quality monitoring sites in listed water bodies in the Santa Maria River Watershed, and Oso Flaco Creek.

Water body	Site	n	Min. (MPN)	Log mean (MPN)	Max. (MPN)	Percent exceedance of 400 MPN/100mL
Oso Flaco Creek	312OFC	15	1	218	35000	40%
Alamo Creek	312ALA	15	23	326	5000	53%
Nipomo Creek	312NIT, 312NIP	28	10	1005	9000	68%
Santa Maria River	312SMA, 312SMI	62	1	788	24000	71%
Blosser Channel	312BCD	11	14	831	30000	55%
Bradley Channel	312BCU	14	30	628	13000	64%

Bradley Canyon Creek	312BCF	7	110	2911	160001	71%
Orcutt-Solomon Creek	312ORC, 312ORI, 312ORB	70	20	802	90000	70%

Staff evaluated CCAMP water quality data collected on each listed water body. These data, along with land use information (discussed further in the *Land Use Data* Section 4.4), are presented below.

Alamo Creek

CCAMP staff collected samples on Alamo Creek at Highway 166 (ALA) between January 2000 and April 2001. CCAMP sites are shown in Table 3. Figure 4 displays a standard-exceedance assessment, which includes a monthly analysis of summary statistics (e.g. median) when multiple monthly data points are available, 25^{th} – 75^{th} percentile, and exceedance amount, along with the water contact water quality objective of 400 MPN/100 mL. Single sample values are displayed as a median when only one monthly value is available.

Eight exceedances of the water quality objective occurred in Alamo Creek. Concentrations were elevated year-round, with highest levels occurring during the wet season (September through January). During most field visits, CCAMP staff observed cattle in the creek or evidence of cattle present (e.g. hoof prints, waste) in the creek.

In an analysis of water quality and land use data, Water Board staff concluded the likely the source of the impairment was activities occurring on rangeland, the primary manageable, or *controllable* land use in this watershed.

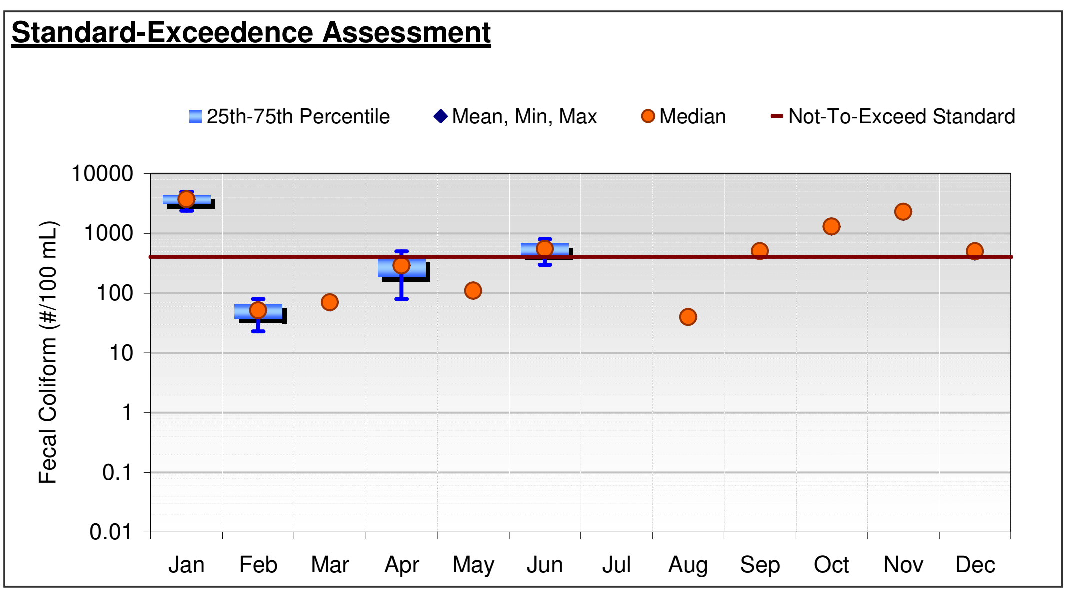


Figure 4. Monthly fecal coliform exceedances on Alamo Creek at Highway 166 (ALA) January 2000 to June 2001.

Nipomo Creek

CCAMP staff collected samples at two sites (NIP and NIT) on Nipomo Creek between January 2000 and February 2001. Log mean concentrations of fecal coliform at both sites are displayed in Figure 5 and combined monthly exceedances are shown in Figure 6. The water quality objective of 400 MPN/100mL is also show.

Concentrations measured upstream at Tefft Street (NIT) were typically higher and more variable than those measured downstream on Nipomo Creek at Highway 166 (NIP). Seven of nine samples exceeded the water quality objective at NIT and eight of fourteen samples exceeded the water quality objective downstream at NIP. Exceedances of the water quality objective occurred at both sites every month with the exception of March 2000.

In an analysis of land use data, Water Board staff determined that Nipomo Creek drained a mosaic of land uses that included numerous potential sources. Land uses upstream of Tefft Street (NIT) included irrigated agriculture (e.g. row crops, nurseries), rangeland, urban areas, and rural residential properties with livestock (e.g. horses, pigs) and potentially failing septic systems. Natural sources included birds and wildlife. CCAMP staff often observed swallows nesting above the creek throughout the dry season at the monitoring site, NIP.

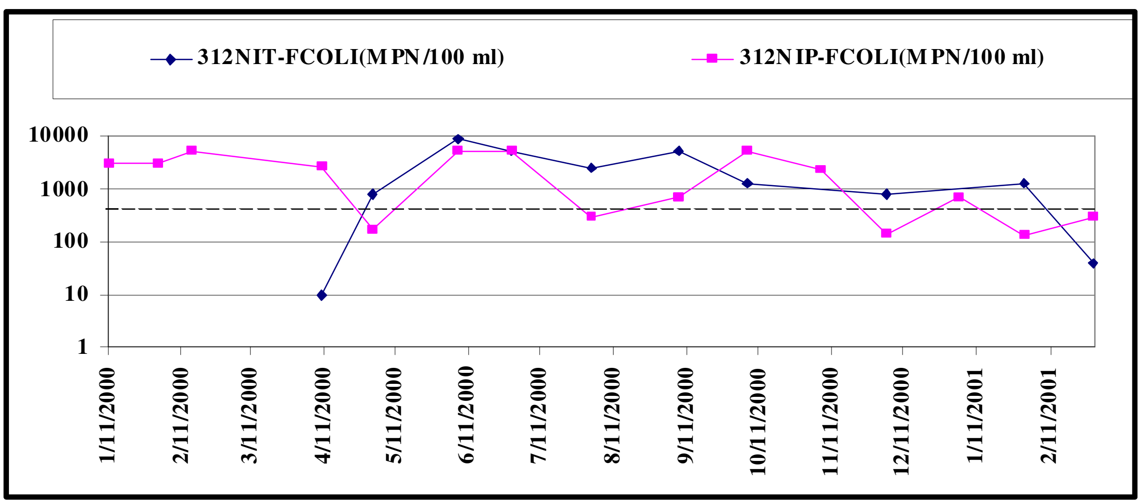


Figure 5. Fecal coliform log means on Nipomo Creek at Tefft Street (NIT) and Nipomo Creek at Highway 166 (NIP) January 2000 to February 2001.

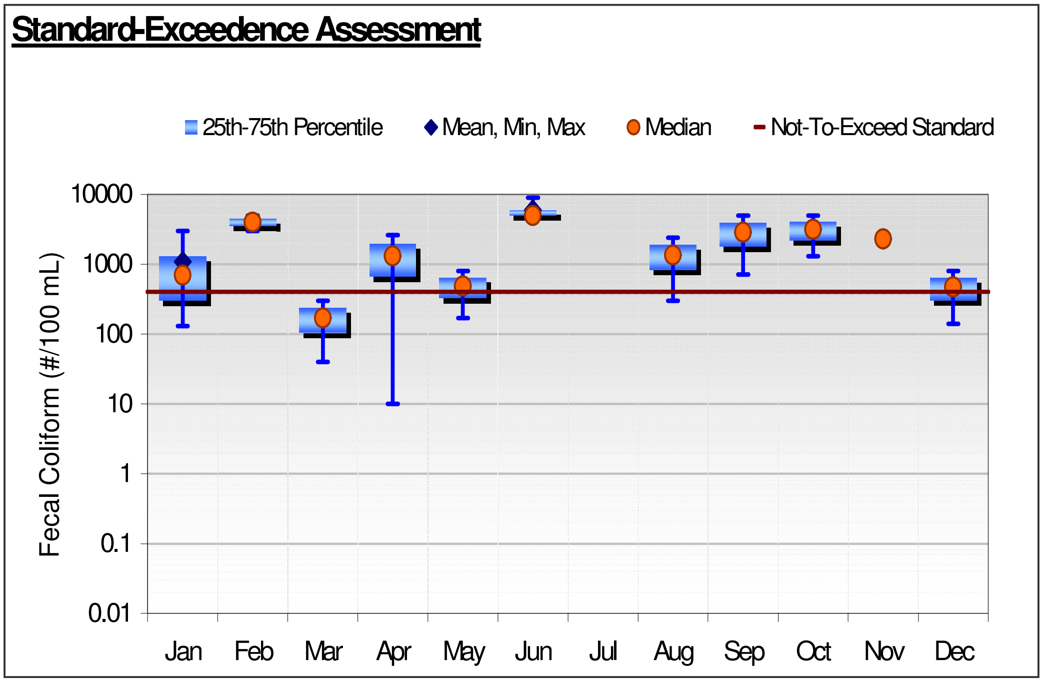


Figure 6. Monthly fecal coliform exceedances on Nipomo Creek at Tefft Street (NIT) and Nipomo Creek at Highway 166 (NIP) January 2000 to February 2001.

Santa Maria River:

CCAMP staff collected samples in the Santa Maria River at Highway 1 (SMI) and further downstream at Rancho Guadalupe Dunes Preserve Road (SMA) between January 2000 and February 2001. Sampling at SMA is continuous on a monthly basis through CCAMP's Coastal Confluences project; data for this site is shown through August 2004 in Figure 7.

Concentrations found at SMA were higher than those found upstream at SMI during 2000-01, with log means of 804 MPN/100 mL and 618 MPN/100 ml respectively. Results of a standard exceedance assessment at both sites are displayed in Figure 8. Fecal coliform concentrations along the Santa Maria River were variable year-round with levels higher during the dry season (April-November), although exceedances were found during every month of the year. During every field visit, CCAMP staff observed cattle in the creek or evidence of cattle present (e.g. hoof prints, waste).

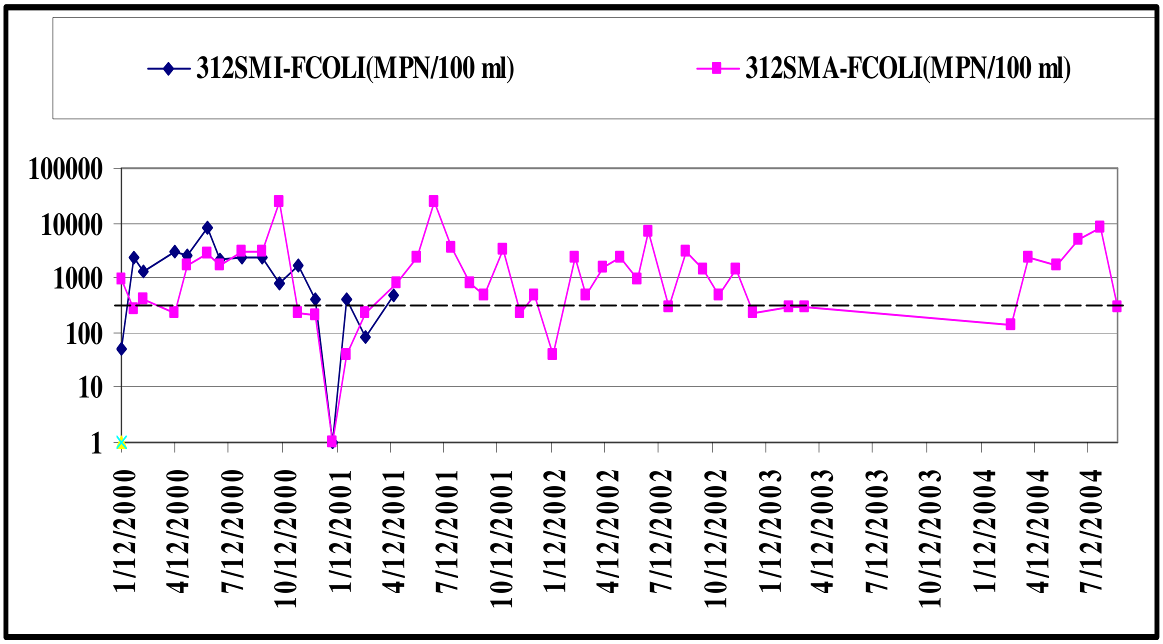


Figure 7. Fecal coliform log means in the Santa Maria River at Highway 1 (SMI) and Santa Maria River at Rancho Guadalupe Dunes Preserve Road (SMA) January 2000 to February 2001.

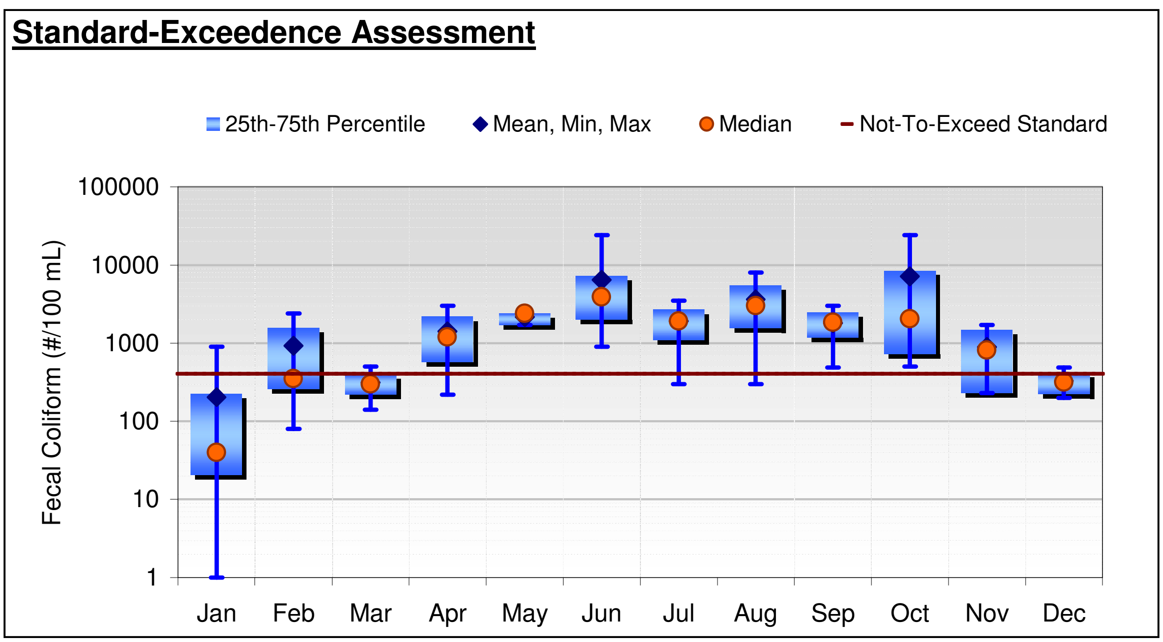


Figure 8. Monthly fecal coliform exceedances in the Santa Maria River at Highway 1 (SMI) and Santa Maria River at Rancho Guadalupe Dunes Preserve Road (SMA) January 2000 to August 2004.

Runoff from the City of Santa Maria drained to the Santa Maria River both directly and through a series of storm water percolation ponds. Staff identified that the primary manageable land uses downstream of the City of Santa Maria in the lower reaches of the

Santa Maria River were rangeland and irrigated agriculture, and concluded that activities occurring on these land uses were likely contributing to the impairment.

<u>Blosser and Bradley Channels:</u>
CCAMP staff collected samples between January 2000 and February 2001 in Blosser Channel and Bradley Channel, two concrete storm water conveyances. Bradley Channel drains to percolation ponds and Blosser Channel drains to the Santa Maria River. Fecal coliform concentrations at both sites are displayed in Figure 9 and results of a standard-exceedance assessment are shown in Figure 10. Levels in Blosser Channel at Rancho Verde (BCD) were higher and more variable than those found in Bradley Channel at Magellan Drive (BCU). Concentrations were typically higher during the dry season (May through October), although exceedances of the water quality objective were found throughout the year with the exception of September.

Both irrigated agricultural and urban land uses drained to these sites. Staff recommends further evaluating these water body segments as to whether or not they support the designated water contact use (REC-1). In fact, Blosser Channel was significantly modified in conjunction with adjacent urban development, and no longer receives year-round flow from adjacent storm water ponds. Staff recommends that we analyze the appropriateness of the beneficial use designations for these water bodies. This is discussed further in Section 7 *TMDL Calculation and Allocations*.

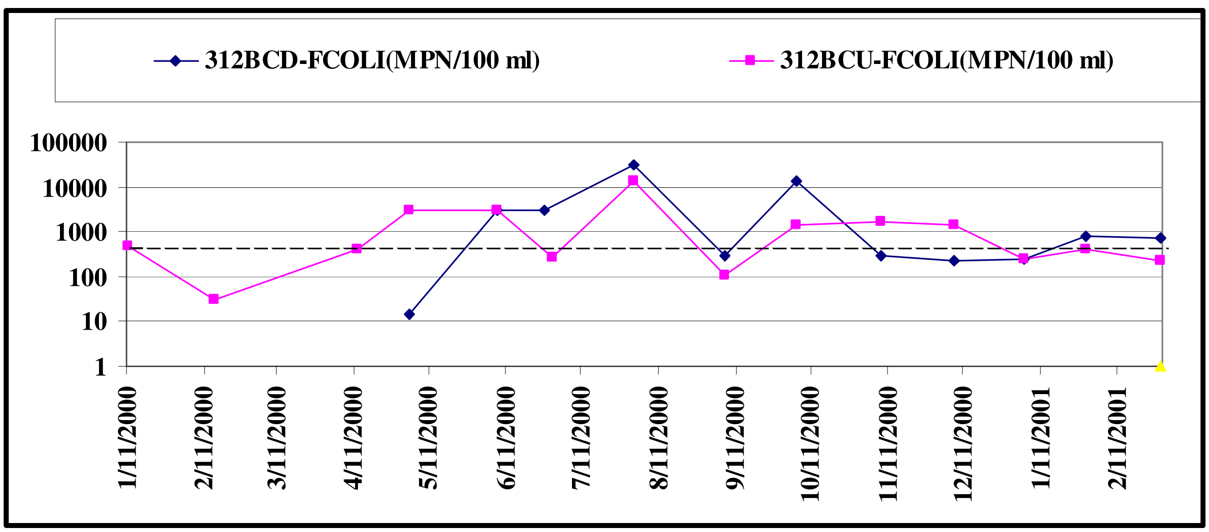


Figure 9. Fecal coliform log means in Blosser Channel at Rancho Verde (BCD) and Bradley Channel at Magellan Drive (BCU) January 2000 to February 2001.

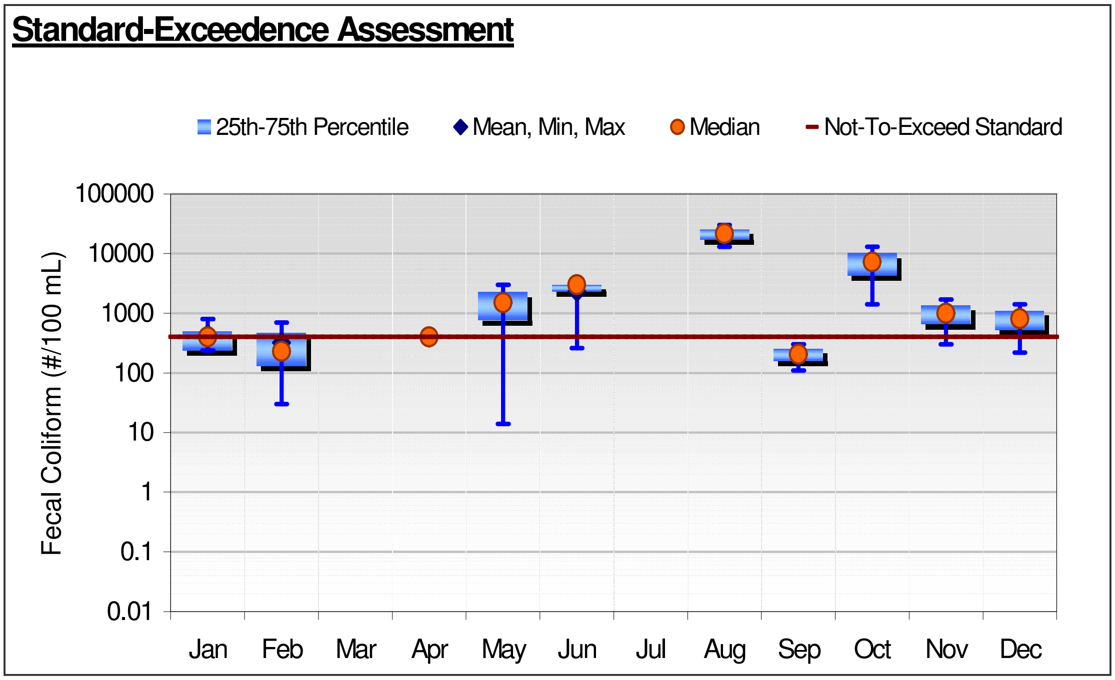


Figure 10. Monthly fecal coliform exceedances in Blosser Channel at Rancho Verde (BCD) and Bradley Channel at Magellan Drive (BCU) January 2000 to February 2001.

<u>Bradley Canyon Creek</u>

CCAMP staff collected samples at Bradley Canyon Creek at Foxen Canyon Road (BCF) between April and December 2000. Monthly concentrations are shown in Figure 11. The figure displays single sample values as medians because with the exception of June, only one set of monthly values are available. Fecal coliform concentrations were elevated above water contact water quality objectives in April, June, September, and November with levels reaching 160,000 MPN/100 mL in September 2000 and 90,000 MPN/100mL in June 2000.

Possible sources included runoff from rangeland, irrigated agriculture (e.g. row crops, vineyards), and rural residential properties (with livestock). There is no riparian vegetation at or upstream of BCF. CCAMP staff attempted to sample upstream of BCF but was unable to gather a representative sample due to either lack of flow or flooding.

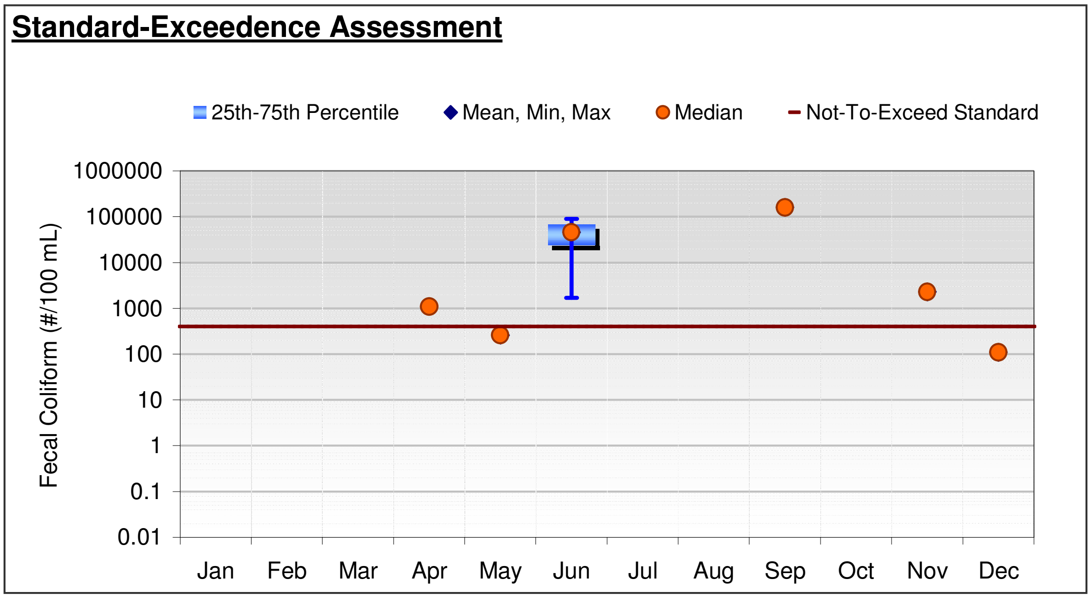


Figure 11. Monthly fecal coliform exceedances at Bradley Canyon Creek at Foxen Canyon Road (BCF) April to December 2000.

<u>Orcutt-Solomon Creek</u>

CCAMP staff collected samples at Orcutt-Solomon Creek between January 2000 and March 2001. Fecal coliform concentrations at three sites are displayed in Figure 12 and results of a standard-exceedance assessment are shown in Figure 13. The most upstream site at Black Road (ORB), a low flowing drainage, exhibited elevated levels year-round, with a log mean of 1,826 MPN/100 mL. Concentrations reached 90,000 MPN/100 mL and 10,000 MPN/100 mL in January and November 2000. Concentrations were higher at the furthest downstream site, Rancho Guadalupe Dunes Preserve Road (ORC) than upstream of that site at Highway 1 (ORI), with log means of 794 MPN/100 mL and 300 MPN/100 mL respectively. Site ORI is the same as the County of Santa Barbara's Project Clean Water Site OR1 discussed in a subsequent section.

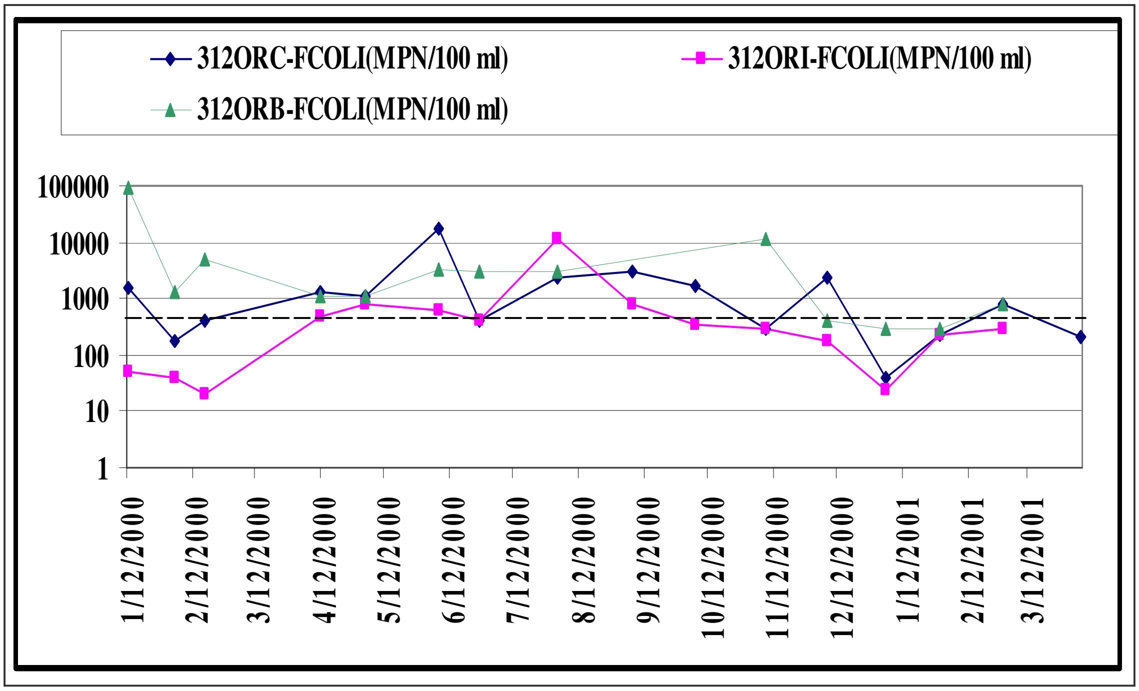


Figure 12. Fecal coliform log means in Orcutt-Solomon Creek at ORC, ORI, and ORB January 2000 to March 2001.

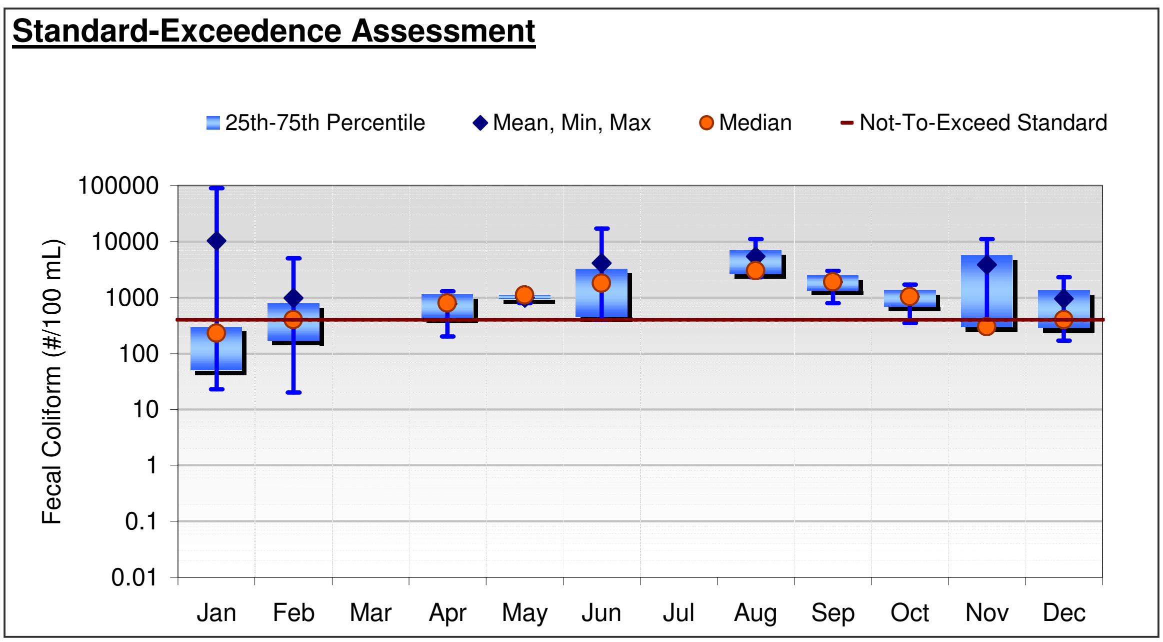


Figure 13. Monthly fecal coliform exceedances in Orcutt-Solomon Creek at ORC, ORI, and ORB January 2000 to March 2001.

Manageable land uses within the Orcutt-Solomon watershed included rangeland, irrigated agriculture, urban, and rural residential with livestock (e.g. horses). Primarily irrigated agriculture and rangeland drained to Orcutt-Solomon Creek in between ORC and ORI;

rangeland drained to ORB. Staff concluded that multiple land uses with various associated activities are likely causing the impairment in Orcutt-Solomon Creek.

Oso Flaco Creek and Little Oso Flaco Creek
CCAMP staff collected samples in Oso Flaco Lake, Oso Flaco Creek, and Little Oso Flaco Creek between January 2000 and March 2001.

Fecal coliform levels in Oso Flaco Lake (OFL) were below water contact water quality objectives, with the exception of two exceedances in Fall 2000. Oso Flaco Lake is not on the 303(d) list for fecal coliform because concentrations typically met water quality objectives. As such, staff did not develop a TMDL for Oso Flaco Lake.

Concentrations on Oso Flaco Creek at Oso Flaco Creek Road (OFC) were elevated above water contact water quality objectives in January 2000 and in May through October 2000. Concentrations at Little Oso Flaco Creek (OFN) were similar, with levels reaching 23,000 MPN/100 mL in May 2000. Fecal coliform concentrations at Oso Flaco Creek and Little Oso Flaco Creek are displayed in Figure 14 and results of a standard-exceedance assessment are shown in Figure 15.

Little Oso Flaco Creek is not specifically listed as impaired on the 303(d) list. Staff concluded that both Oso Flaco Creek and its tributary, Little Oso Flaco Creek were impaired. As such, TMDLs were developed for both water bodies

In an analysis of land uses, staff concluded that the primary land use within the Oso Flaco watershed was irrigated agriculture. Staff also identified rural residential/urban land uses on the Nipomo Mesa that drain to the Oso Flaco watershed via a storm water conveyance system.

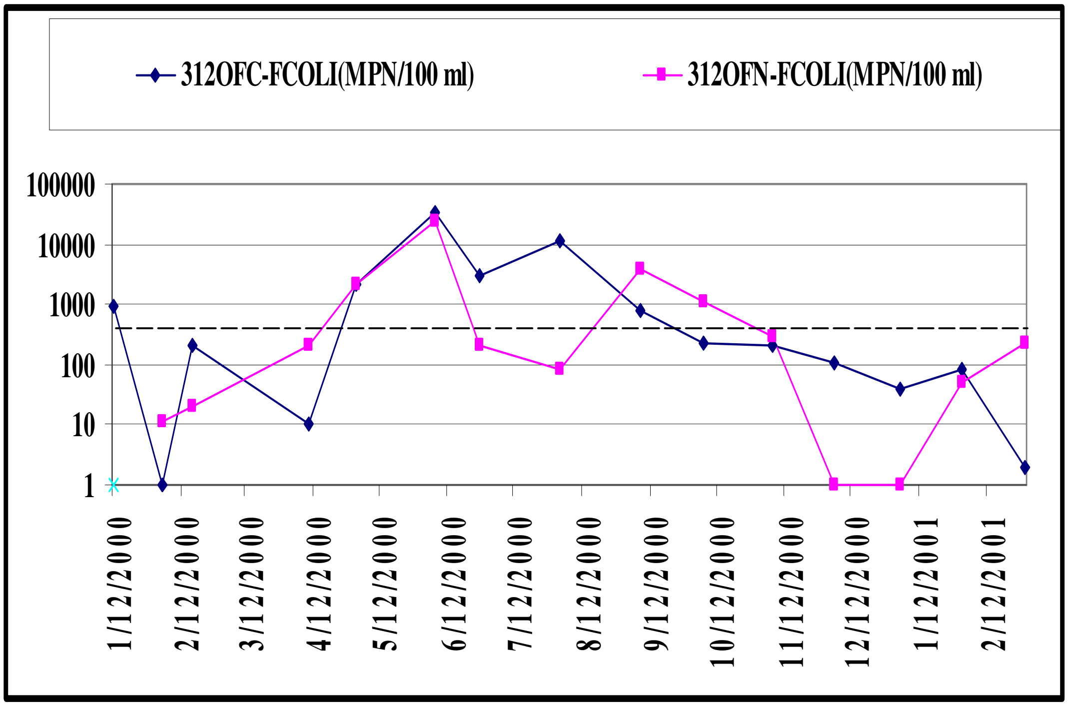


Figure 14. Fecal coliform log means in Oso Flaco Creek (OFC) and Little Oso Flaco Creek (OFN) January 2000 to March 2001.

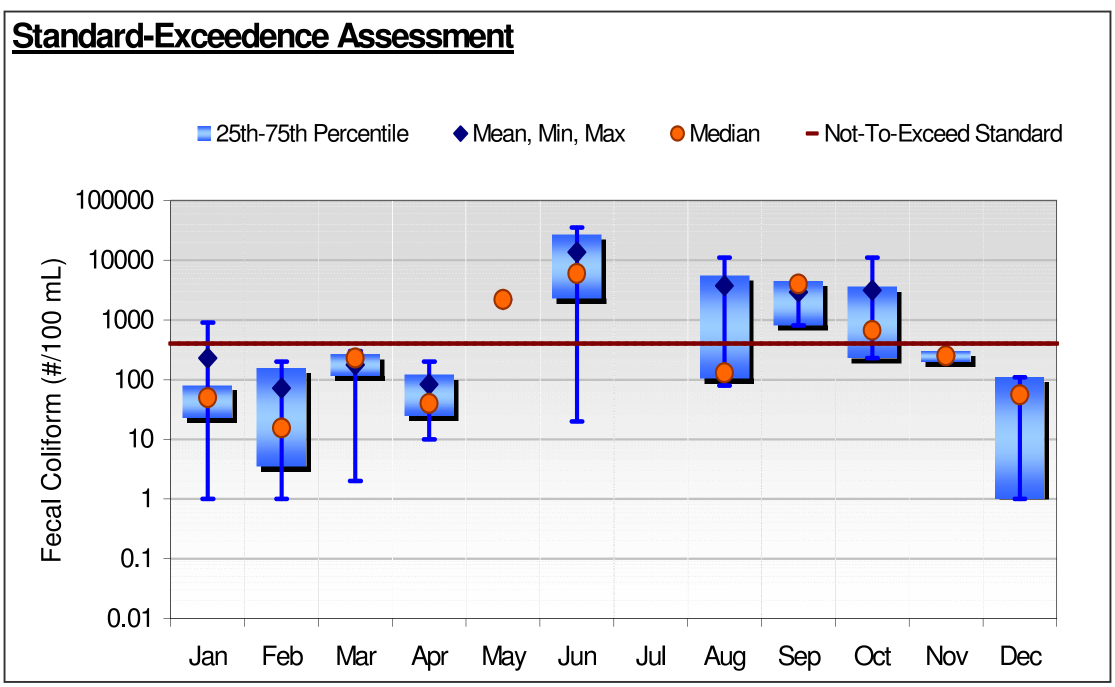


Figure 15. Monthly fecal coliform exceedances in Oso Flaco Creek and Little Oso Flaco Creek January 2000 to March 2001.

b. **Water Board storm-event monitoring**

Water Board staff designed and implemented a plan for sampling and analyzing additional water column grab samples using the Colilert method, a screening tool that provides results for total coliform and *E. coli*. The protocols for sample collection and analysis of pathogens are detailed in the quality assurance study plan for the project (Water Board, 2004). The objective of the additional monitoring was to evaluate relative bacterial contributions from urban and irrigated agricultural areas. The plan included wet and dry season sampling for bacteria counts. Additionally, staff wanted to determine whether genetic analysis of bacteria to determine their animal host was necessary to complete the analyses.

Staff conducted field monitoring in December 2004, and February, March, and May 2005. Staff abandoned the dry weather sampling due to the lack of flowing water and assurance that additional data would provide information to further differentiate sources. Table 5 displays a summary of data collected from various sources and locations in the Oso Flaco and Santa Maria watersheds.

Table 5. Summary of storm events sites and *E. coli* concentrations within the Oso Flaco and Santa Maria watersheds, December 2004, and February, March, and May 2005.

Watershed/ Water body	Station (s)	Primary land use/location within drainage area	No.	Min. (MPN/100 mL)	Log mean. (MPN/100 mL)	Max. (MPN/100 mL)
Oso Flaco / Oso Flaco Creek						
	312NMRUS; 312NMR; 312NMRDS	Urban runoff from Nipomo Mesa via storm water collection system on Division Road	11	1203.3	1,997.3	>2419.2
	312BSR	Urban and agricultural runoff in drainage/tributary to Oso Flaco Creek	6	36	443.8	>2419.2
	312OFC	Oso Flaco Creek downstream of confluence with drainage/tributary	5	157.6	298.2	613.1
Santa Maria/ Bradley Channel						
	312BCAgF1; 312BCAgF2; 312BCSD1; and 312BCSD2	Irrigated agricultural runoff from field and via surface drains	6	196.8	452.4	686.7
	312BCUUS	Receiving water within Bradley Channel Upstream of City of SM; South of Jones @ Hwy 101	4	108	605.2	2419.2
	312BCUDS	Receiving water within Bradley Channel Downstream of City of SM; Western Avenue North	4	307	1,073.5	>2419.2

Of forty-three samples taken during the wet season from receiving water and agricultural and urban discharges, twenty-nine exceeded the single sample value of 400 MPN/100mL for *E. coli*. Note that staff compared levels to receiving water criteria and water quality objectives (*E. coli* of 235MPN/100 mL and 400MPN/100 mL) for the purpose of evaluating potential sources.

<u>Urban runoff</u>

Urban runoff and samples taken downstream of urban areas had higher levels of *E. coli* than any other sites sampled, with all samples exceeding 400 MPN/100 mL. All samples taken from Bradley Channel downstream of the City of Santa Maria were higher than samples taken from Bradley Channel upstream of the City of Santa Maria. Additionally, there was often a wide range in the level of *E. coli* detected throughout the sampling period, with higher values found earlier in the wet season than later. For example, *E. coli* concentrations found upstream of the City of Santa Maria ranged from 2,419 MPN/100 mL in February to 108 MPN/100 mL in May 2005.

The Nipomo Mesa discharged storm water to a storm water collection system during storm events. This discharge flowed through drainages adjacent to irrigated agriculture, which ultimately reached Oso Flaco Creek. Samples taken of urban runoff from the Nipomo Mesa always exceeded the criteria for *E. coli*, and were consistently higher than samples taken downstream in a drainage/tributary receiving both urban and agricultural runoff. Four of five samples taken from Oso Flaco Creek during this period exceeded the criteria for *E. coli* of 235 MPN/100 mL, with only one exceeding 400 MPN/100 mL. Concentrations were lower than those found in the contributing drainage, with a log mean of 298.2 MPN/100 mL. Figure 16 shows *E. coli* concentrations during storm events.

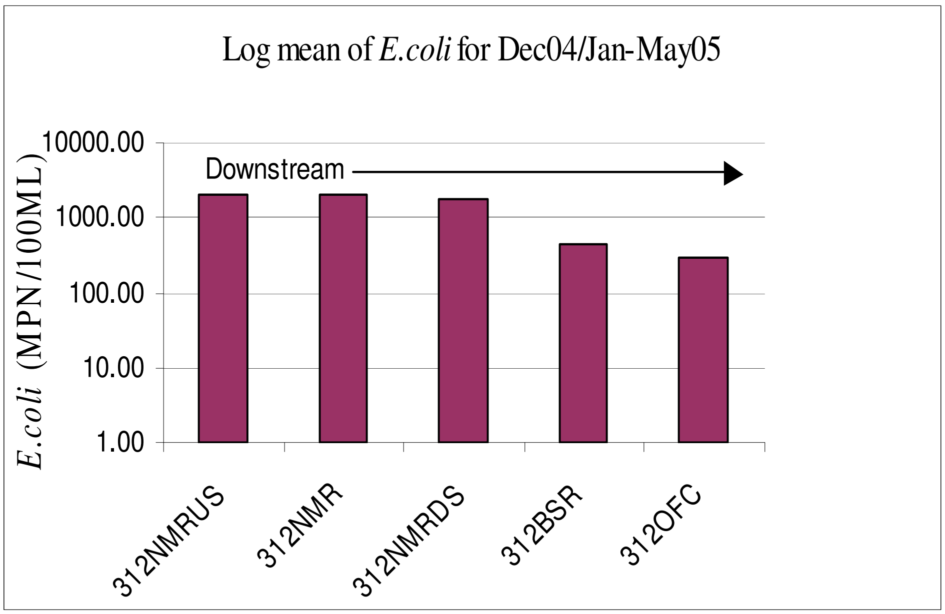


Figure 16. Log mean of *E. coli* (MPN) during storm events at monitoring sites in the Oso Flaco watershed December 2004 to May 2005.

<u>Agricultural runoff</u>

Sampling of irrigated agriculture runoff was limited spatially and temporally, with only two storms sampled from one type of crop operation. Samples taken from surface drains along with runoff directly from the agricultural field had a log mean of 452 MPN/100 mL (Table 5). Four out of six samples exceeded the *E. coli* criteria of 400 MPN/100 mL, and five out of six samples exceeded the *E. coli* criteria of 235 MPN/100 mL. Despite the limited measurements, staff concluded the following about irrigation runoff quality in comparison to the water quality of the listed water bodies: there was no formal system to measure the rates of irrigation return flows within the watershed, and *E. coli* concentrations in runoff were elevated above criteria, but were much less than the receiving water concentrations and runoff from urban areas.

Flow in Bradley Channel upstream from the City of Santa Maria was almost exclusively from irrigated agriculture runoff. Concentrations of *E. coli* upstream were elevated, with four of six samples exceeding both *E. coli* criteria (Table 5).

Water Board staff also sampled soils in May 2005. *E. coli* concentrations in sediment collected from Bradley Channel and Oso Flaco Creek were 517 MPN and 133 MPN/100 mL respectively.

The pathogenic O157:H7 species of *E. coli* were found in other watersheds in the Central Coast Region that have similar land uses to the Santa Maria. As a result, staff also sent eight samples from four sites to the U.S. Department of Agriculture laboratory in Albany, California for speciation for the O157:H7 *E. coli.* All samples were negative for O157:H7.

While genetic methods are among the most definitive ways to determine relative contribution of sources of *E. coli*, Water Board staff concluded that conducting such a study may not be realistic nor justified based on the fact that 1) existing studies can be transferable to this watershed, and 2) multiple land uses with numerous sources drain to these watersheds. Furthermore, the information may not change the implementation approaches. Results from two genetic studies that can be applied to this watershed are included in the Section 5. *Source Analysis*.

c. <u>City of Santa Maria storm event monitoring</u>

The City of Santa Maria (City) collected data during the wet seasons of 2004-06 as part of their storm water regulatory program. Table 6 shows a summary of fecal coliform concentrations within the City of Santa Maria. Figure 17, Figure 18, and Figure 19 show locations of sample stations. The City plans to continue monitoring efforts indefinitely, with a minimum of three sampling events per wet season. While the sample size of data from the City of Santa Maria limits the ability to draw strong conclusions, the data suggested that both urban runoff and irrigated agriculture were contributing to elevated fecal coliform concentrations in the Santa Maria watershed. Additional sampling will provide information to further characterize urban and agricultural inputs.

Table 6. Summary of Fecal Coliform concentrations within the City of Santa Maria

Station	Drainage area primary land uses	No.	Min. (MPN)	Log mean. (MPN)	Max. (MPN)
Prell Basin	Primarily runoff from irrigated agriculture; representative of flows that enter the City.	5	500	1,226	2,400
Hobbs Basin	Urban run off; representative of urban flows leaving the City and flowing to the Santa Maria River	4	500	2,527	17,000
Main St. Channel North and South	Two channels that discharge to the Santa Maria River; representative of urban and agriculture	10	900	8,666	160,000

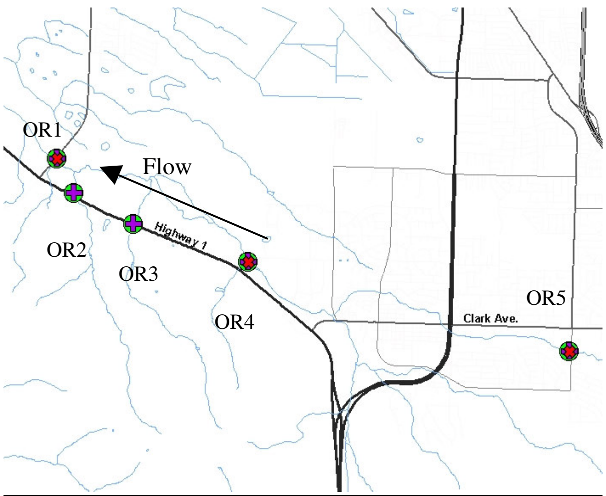
Figure 17. Location of the Prell Basin sampling station within the City of Santa Maria.

Figure 18. Location of the Hobbs Basin sampling station within the City of Santa Maria.

Figure 19. Location of the Main St. Channel North sampling station within the City of Santa Maria.

d. **Orcutt-Solomon Creek storm event monitoring**

The County of Santa Barbara's Project Clean Water sponsors studies to help identify sources of pollution that lead to beach closures and to develop an understanding of how those pollutants move through the environment. Project Clean Water conducted water quality monitoring in Orcutt-Solomon Creek during nine storm events between February 2000 and February 2003. Site locations are show in Figure 20. Project Clean Water sampling sites on Orcutt-Solomon Creek. Site OR1 is the same as CCAMP site ORI, which was monitored on a monthly basis. Results are displayed in Figure 21 and Table 7.



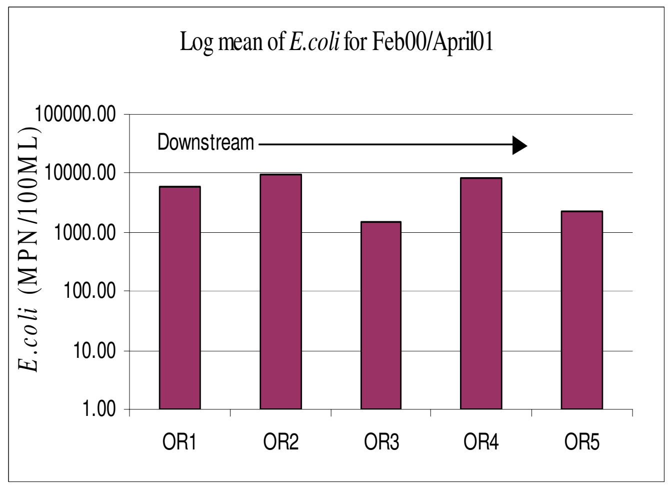


Figure 20. Project Clean Water sampling sites on Orcutt-Solomon Creek.

Figure 21. Log mean of *E. coli* on Orcutt-Solomon Creek.

Table 7. Summary of *E. coli* levels in Orcutt-Solomon Creek during storm events

Station	Drainage area primary land uses	No.	Min. (MPN)	Log mean. (MPN)	Max. (MPN)
OR1	rangeland and irrigated agricultural	9	1,014	6,057	38,730
OR2	rangeland and irrigated agricultural	5	74	9,453	1,046,200
OR3	golf course	4	17	1,474	72,700
OR4	rangeland and urban/ rural residential	6	776	8,171	92,080
OR5	urban and commercial	9	31	2,257	155,310

Log mean of *E. coli* levels at stations OR1, OR2 and OR4 were higher than those found at stations OR3 and OR5. Station OR3 drained a golf course and Station OR5 drained urban land uses. Staff concluded that levels were likely higher at OR1, OR2 and OR4 because they drained areas with large rangeland components.

e. **Case Study: Rangeland management measure implementation monitoring**

In a study conducted in the Morro Bay watershed (National Monitoring Program, 2003), Water Board staff collected fecal coliform data to evaluate the effectiveness of rangeland management practices. The data demonstrated that fecal coliform in the creek was reduced significantly when management practices were implemented. This suggests that rangeland fecal coliform loading was causing increases in fecal coliform concentrations.

Summary of Water Quality Data

Samples for fecal coliform and/or *E. coli* were collected as part of numerous efforts to confirm impairment of the listed water bodies and further identify sources. Certain sites experienced a pattern of seasonal variation, while others were elevated year-round. Specific conclusions from the water quality data discussed above, along with the information presented below are summarized in Section 4.6 *Data Analysis Summary*.

4.4. Land Use Data

Water Board staff considered the spatial data required for the following purposes to prepare this report: delineation of watershed boundaries; compilation of land use tables; preparation of orientation maps, and presentation of hydrologic and transportation networks. Water Board staff used watershed areas to describe the condition of the watershed and to interpret the relative effects of land use on bacteria levels. Water Board staff used multiple USGS 30-meter Digital Elevation Models to determine sub-watershed boundaries for the listed water bodies. Water Board staff aggregated Multi-Resolution Land Characterization (MRLC) land use classifications into land use categories. The categories included the following: irrigated agricultural, rangeland, urban/commercial, rural residential, and open space. Table 8 displays land uses (acres) by main watersheds and subwatersheds, including listed water bodies.

Table 8. Land uses in subwatersheds in the Oso Flaco and Santa Maria watersheds.

Subwatershed	Irrigated Agricultural	Rangeland	Urban/ Commercial	Rural Residential	Open Space	TOTAL AREA
	Area and Percent					
Sisquoc	7,825	82,067	207	556	211,152	**301,807**
	3%	*27%*	*0%*	*0%*	*70%*	
Cuyama	36,042	269,470	769	385	366,720	**673,386**
	5%	*40%*	*0%*	*0%*	*54%*	

Alamo Creek	382	21,467	1	1	35,946	**57,796**
	1%	*37%*	*0%*	*0%*	*62%*	
Santa Maria River	19,785	16,539	621	632	7,894	**45,470**
	44%	*36%*	*1%*	*1%*	*17%*	
Nipomo Creek	9,369	3,458	329	359	985	**14,501**
	65%	*24%*	*2%*	*2%*	*7%*	
Channels (Blosser, Bradley, and Main)	3,377	686	2,564	2,128	581	**9,336**
	36%	*7%*	*27%*	*23%*	*6%*	
Bradley Canyon Creek	4,402	5,317	152	213	930	**11,015**
	40%	*48%*	*1%*	*2%*	*8%*	
Orcutt-Solomon Creek	20,980	25,297	2,575	3,001	5,716	**57,569**
	36%	*44%*	*4%*	*5%*	*10%*	
Santa Maria River Mouth	4	510	1	1	650	**1,165**
	0%	*44%*	*0%*	*0%*	*56%*	
Oso Flaco Creek*	5,980	1,043	142	86	1,801	**9,051**
	66%	*12%*	*2%*	*1%*	*20%*	
Total	**108,147**	**425,856**	**7,362**	**7,361**	**632,379**	**1,181,105**
	9%	***36%***	***1%***	***1%***	***54%***	

** includes estimated area draining Nipomo Mesa through storm-drain conveyance system.*

Table 8 displays land uses in each subwatershed, including those draining listed water bodies. Open space, rangeland, and irrigated agriculture remained the largest land uses despite continued development pressure from population growth. Note that the Sisquoc and Cuyama water bodies were not listed as impaired, with the exception of Alamo Creek, a tributary to the Cuyama River (shown previously in Figure 1), According to staff's land use analysis, the Sisquoc and Cuyama watersheds were dominated by open space, with large rangeland components.

4.5. Relationship of Genetic Studies to Land Use

Water Board staff evaluated results of genetic fingerprinting studies conducted in Central Coast Region watersheds to characterize sources of bacterial contamination in Santa Maria and Oso Flaco watersheds. The discussion below includes an analysis of land use influence on bacteria concentrations in two watersheds with similar land uses to Oso Flaco and Santa Maria: the Watsonville Sloughs and the Morro Bay watershed.

A study conducted in Watsonville (Water Board, 2005) determined that exceedances of bacteria water quality objectives were associated with all land uses. In an examination of the association of dominant land use in subwatersheds with exceedances of water quality objectives, staff observed that exceedances may occur in summer and/or winter in water bodies regardless of dominant land uses. Table 9 describes land uses surrounding sampling locations and results of genetic analyses.

Staff also found a consistent depression of the bird component of bacteria with wet conditions in Watsonville. This pattern was also found in the Morro Bay watershed. Data suggested that winter runoff introduced additional pathogenic material from non-bird sources, reducing the proportion of avian, or bird bacteria from 98 to 38 percent. While this confirms contributions from terrestrial sources, these data suggested that they may not be influenced by land use. Stated another way, terrestrial sources (dog, bovine, human) were not well correlated with available land use data.

The data from Watsonville Sloughs also indicated that urban land uses were commonly associated with concentrations of *E. coli* in excess of water quality objectives. Furthermore, the analysis of genetic sources relative to land uses revealed that urban uses were implicated as sources of controllable fecal material from dogs and humans.

Table 9. Land uses surrounding sampling locations for genetic source tracking and results of genetic analysis for wet and dry seasons in Watsonville Sloughs, 2003.

<table>
<tr><th colspan="2" rowspan="2">Land use
(Percent of subwatershed)</th><th colspan="2">Rabbits</th><th colspan="2">Humans</th><th colspan="2">Dogs</th><th colspan="2">Avian</th><th colspan="2">Bovine</th></tr>
<tr><th>Dry</th><th>Wet</th><th>Dry</th><th>Wet</th><th>Dry</th><th>Wet</th><th>Dry</th><th>Wet</th><th>Dry</th><th>Wet</th></tr>
<tr><td colspan="2">Struve Slough (STR-CHE)</td><td colspan="10">Percent of Sample</td></tr>
<tr><td>Urban</td><td>45%</td><td rowspan="3">0</td><td rowspan="3">0</td><td rowspan="3">0</td><td rowspan="3">3</td><td rowspan="3">2</td><td rowspan="3">21</td><td rowspan="3">98</td><td rowspan="3">38</td><td rowspan="3">0</td><td rowspan="3">38</td></tr>
<tr><td>Commercial</td><td>45%</td></tr>
<tr><td>Agricultural</td><td>10%</td></tr>
<tr><td colspan="12">Lower Watsonville Slough (WAT-SHE)</td></tr>
<tr><td>Agricultural</td><td>85%</td><td rowspan="2">0</td><td rowspan="2">0</td><td rowspan="2">0</td><td rowspan="2">0</td><td rowspan="2">6</td><td rowspan="2">28</td><td rowspan="2">94</td><td rowspan="2">20</td><td rowspan="2">0</td><td rowspan="2">52</td></tr>
<tr><td>Undeveloped</td><td>15%</td></tr>
<tr><td colspan="12">Upper Harkins Slough (HAR-HAR)</td></tr>
<tr><td>Undeveloped</td><td>65%</td><td rowspan="4">0</td><td rowspan="4">0</td><td rowspan="4">1</td><td rowspan="4">2</td><td rowspan="4">47</td><td rowspan="4">9</td><td rowspan="4">52</td><td rowspan="4">18</td><td rowspan="4">0</td><td rowspan="4">71</td></tr>
<tr><td>Grazing</td><td>20%</td></tr>
<tr><td>Rural Residential</td><td>10%</td></tr>
<tr><td>Agricultural</td><td>5%</td></tr>
</table>

Source: Hager, et al., 2004, and SH&G, et al., 2003.

A genetic fingerprinting study was conducted in the Morro Bay watershed (California Polytechnic State University, 2002). Data collected from Chorro and Los Osos Creeks in the Morro Bay watershed indicated that bovine, or cow sources contributed the majority (31%) of *E. coli* in Chorro Creek, a watershed with 63% rangeland. Bovine sources contributed similar levels of *E. coli* during both wet and dry weather sampling. In Los Osos Creek, a watershed with a mixture of urban, rangeland, agriculture, no one source exceeded 20% of the total. Table 10 describes land uses surrounding sampling locations and results of genetic analyses in Chorro and Los Osos Creeks.

Table 10. Land uses surrounding sampling locations for genetic source tracking and results of genetic analysis in Chorro and Los Osos Creeks, 2002.

<table>
<tr><th colspan="2">Land use
(Percent of subwatershed)</th><th>Avian</th><th>Bovine</th><th>Dog</th><th>Human</th></tr>
<tr><td colspan="6">Chorro Creek</td></tr>
<tr><td>Urban</td><td>5.4%</td><td rowspan="5">11</td><td rowspan="5">31</td><td rowspan="5">6</td><td rowspan="5">13</td></tr>
<tr><td>Rangeland</td><td>62.8%</td></tr>
<tr><td>Agricultural</td><td>6.1%</td></tr>
<tr><td>Brushland</td><td>17.0%</td></tr>
<tr><td>Woodland</td><td>8.7%</td></tr>
<tr><td colspan="6">Los Osos Creek</td></tr>
<tr><td>Urban</td><td>16.9%</td><td rowspan="5">20</td><td rowspan="5">8</td><td rowspan="5">12</td><td rowspan="5">19</td></tr>
<tr><td>Rangeland</td><td>37.3%</td></tr>
<tr><td>Agricultural</td><td>18.8%</td></tr>
<tr><td>Brushland</td><td>3.3%</td></tr>
<tr><td>Woodland</td><td>16.8%</td></tr>
</table>

The land uses (rangeland, urban/commercial, rural residential, and irrigated agriculture) addressed in this project study area are similar to those in the Watsonville and Morro Bay watersheds. While it was not possible to definitively determine which sources originate from each land use because each watershed had multiple land uses, some of the conclusions from these studies were transferred to the watersheds addressed in this report. These are summarized in the following section.

4.6. Data Analysis Summary

Samples for fecal coliform and/or *E. coli* were collected as part of numerous efforts to isolate the location of the source by detecting differences and increases between sites and in direct discharges. Staff concluded the following from the data presented above:

- Watersheds that are not impaired (e.g. Cuyama and Sisquoc) contain the largest open space (e.g. shrub, forest) areas.
- Little Oso Flaco Creek was not specifically named on the 303(d) list, but is impaired. As such, a TMDL was developed for this water body.
- Fecal coliform concentrations in Alamo Creek are elevated year-round with levels higher during the wet-season; the primary managed land use is rangeland, and is likely the primary source of the impairment.
- The Santa Maria River is impaired by fecal coliform year-round, with concentrations higher during the dry-season; rangeland, urban, and irrigated agricultural land uses likely contribute to the impairment.
- The channels (Bradley and Blosser) draining to the Santa Maria River are impaired by fecal coliform year-round, with concentrations higher during the dry-season; urban land uses are likely the primary land use contributing to the impairment.
- Nipomo Creek, Orcutt-Solomon Creek, and Bradley Canyon Creek are impaired by fecal coliform year-round; these watersheds have a mosaic of irrigated agriculture and rangeland, along with rural residential land uses.

- *E. coli* concentrations in runoff from an irrigated agriculture area are elevated, but concentrations are much lower than those found in discharges from urban areas and in receiving water.
- *E. coli* concentrations downstream of urban areas are higher than concentrations upstream, and higher than those draining agriculture.
- Discharges from the rural residential area of Nipomo Mesa and agricultural discharges are elevated, but they are not causing exceedances in Oso Flaco Creek during storm-events.
- Urban storm water discharges from the rural residential area of Nipomo Mesa to Oso Flaco watershed do not occur during dry periods; irrigated agricultural discharges occur during both wet and dry seasons in the Oso Flaco watershed.
- *E. coli* concentrations in runoff to Orcutt-Solomon Creek from rangeland, irrigated agriculture, and rural residential land uses were higher than those draining urban/commercial and a golf course.
- Data indicate that elevated levels are found at locations draining primarily rangeland, and that this land use can contribute significant levels of bacteria.
- Irrigated agriculture is likely contributing to fecal coliform levels, but absolute conclusions cannot be drawn as to the significance and origin of the source. However, without sufficient data indicating that this land use is not a significant source, it warrants inclusion as a source of bacteria.
- Rural residential land uses are likely contributing to fecal coliform levels, but conclusions cannot be drawn as to the significance and origin of the sources (e.g. farm animals, individual septic systems). Nonetheless, without data indicating that activities that typically occur on this land use are not significant sources, they cannot be ruled out.
- Rangeland, urban/commercial, rural residential, and irrigated agricultural land uses are treated as contributing fecal coliform to the listed water bodies in this project.
- The O157:H7 specie of *E. coli* was not found in a limited sample size taken within the Santa Maria watershed.

- While genetic methods are among the most definitive ways available today to determine relative contribution of sources of *E. coli*, Water Board staff concluded a genetic study was not warranted to proceed with TMDL development and begin implementation. Transferable conclusions from previous genetic studies included the following:

    - Sources (e.g. bovine, human) can originate from watersheds draining multiple land uses and are likely originating from more than one land use.
    - While sources are not well correlated with land use data, all land uses are associated with exceedances of water quality objectives.
    - Seasonality is watershed-specific: In Watsonville, runoff during the wet season was likely due to more controllable sources, and different sources were prevalent during wet and dry periods regardless of dominant land uses. In the Morro Bay watershed, there were no significant differences in sources between wet and dry periods.

- Watersheds with larger rangeland components contribute higher bovine sources.
- Exceedances of water quality objectives can be solely caused from natural sources (birds).

5. SOURCE ANALYSIS

The purpose of the Source Analysis is to identify sources and assist in allocating appropriate responsibility for actions needed to reduce these sources. Water Board staff relied on information presented in the *Data Analysis* section and considered the following:

- monitoring efforts to isolate specific causes of high bacteria loads,
- relationships between seasonal conditions and bacteria levels,
- connections between land use and bacteria concentrations,
- connections between land use and genetic sources, and
- uncontrollable, natural sources.

This section provides information on the potential influence of channel characteristics, land uses, and permitted facilities and entities on bacterial concentrations, and identifies the sources.

5.1. Potential Influence of Channel Characteristics on Bacteria Concentrations

Staff evaluated several aspects of the hydrology and specific channel characteristics to determine if and how that might influence bacteria concentrations. The hydrology of the Santa Maria River and listed water bodies within the watershed, and of the Oso Flaco watershed have been significantly altered by people. Based on a Geographic Information System (GIS) analysis of digital elevations, staff observed that creek channels have been moved, watershed areas modified, and urban drainages crossed watershed boundaries. Within the City of Santa Maria, staff observed that some water body segments consisted of concrete-lined channels dominated by urban runoff during rainfall events. Additionally, staff determined that creeks in other parts of the Santa Maria watershed and in the Oso Flaco watershed lacked riparian cover that may lead to increased temperatures and a warm environment conducive to bacteriological reproduction. Furthermore, staff observed slow flowing, and stagnant water in low elevations. Staff concluded that these conditions may contribute to elevated fecal coliform concentrations in-stream, but the extent of the influence from these factors is unknown.

5.2. Potential Influence of Land Use on Bacteria Concentrations

This section discusses the influence of land uses on fecal coliform. *Natural*, uncontrollable sources (e.g. wildlife) can originate from each of the land uses discussed below.

Bacterial sources from rangeland, in part, originate from cattle feces entering the water body. The type of management measures implemented (e.g. rotational grazing, cattle exclusion, off-stream water sources) can reduce the rate of fecal coliform loading.

Conventional agricultural operations typically use inorganic fertilizers rather than land-applied manure. Some irrigated agricultural operations may, however, apply non-sterile manure or other incompletely composted organic materials for fertilizer or soil amendment that can contain bacteria. Agricultural field workers may be a potential source of human pathogens if they do not use portable toilets provided during field operations.

Domestic animals are a source typically associated with urban land uses where the highest concentrations of pets are found, but this source can potentially be associated with all land uses. Pet waste enters waterways through conveyance by storm water from the location where it is deposited, including trails frequented by people hiking with their pets, stray or feral animals, and residences adjacent to waterways.

Human sources typically originate from urban areas via storm water runoff, or homeless encampments, and from rural areas via failing individual sewage disposal systems.

Sources may also include small livestock operations such as those for horses or chickens and other farm animals. Manure from these operations is a potential source of bacteria as well.

5.3. Potential Influence of Permitted Facilities and Entities on Bacteria Concentrations

Facilities Subject to Discharge Permits

The Water Board issues Waste Discharge Requirements (WDRs) for several facilities in the Santa Maria and Oso Flaco watersheds. Numerous facilities (e.g. onsite systems for schools, food processing plants) are permitted for discharge to land.

Several of the facilities in the Santa Maria watershed (City of Santa Maria, City of Guadalupe, Laguna County Sanitation District, and Nipomo Community Services District wastewater treatment plants) are authorized to discharge treated municipal wastewater to land where such discharges are likely to percolate to groundwater. Discharge of municipal wastewater to surface water bodies is prohibited. Each municipality is responsible for operation of the collection system. Dischargers will be developing collection system management plans during renewal of their permits.

Permitted discharges to surface waters include water supply discharges, fire hydrant testing, and vegetable cooling (ice melt), none of which are likely sources of fecal coliform bacteria in the listed water bodies.

Staff concluded that neither permitted facilities nor the municipal collection systems are sources of fecal coliform in the listed water bodies.

Municipalities Subject to Storm Water Permits

The Water Board will be regulating storm water discharge through the issuing of National Pollution Discharge Elimination Permits (NPDES) storm water discharge permits to several municipalities in the Santa Maria and Oso Flaco watersheds. The County of San Luis Obispo, the County of Santa Barbara, and the City of Santa Maria have not previously been required to obtain permit coverage. Upon Water Board approval of their Storm Water Management Plans, they will be covered under a General Municipal Separate Storm Sewer System (MS4) Permit. The General Permit requires the dischargers to develop and implement a Storm Water Management Plan/Program. Water Board staff anticipates permit coverage will begin by September 2006.

Several unincorporated areas of the watersheds will be covered in the permit. The County of San Luis Obispo permit will include the Nipomo Mesa and "old town" Nipomo. The County of Santa Barbara permit will include Orcutt. The City of Guadalupe drains to the Santa Maria River, but will not be covered by the first five-year term of the MS4 permit.

5.4. Potential Influence of Individual Sewage Disposal Systems on Bacteria Concentrations

Human sources of bacteria can originate from failing individual sewage disposal systems. The Counties of San Luis Obispo and Santa Barbara regulate individual sewage disposal systems within the rural areas of the Santa Maria River and Oso Flaco watersheds.

The Basin Plan includes a discharge prohibition from individual sewage disposal systems in the most densely developed portions of the community of Nipomo. The Nipomo Community Services District surveyed and confirmed that all residences within the prohibition zone are connected to the sewage treatment plant or are being required by the Nipomo Community Services District to connect.

5.5. Source Analysis Summary

Bacteria levels throughout the Santa Maria and Oso Flaco watersheds were elevated and varied by season, and a multitude of land uses drained to each of the listed water bodies. Despite multiple sampling efforts, the outcomes did not definitively specify relative sources of fecal coliform from each land use, but rather confirmed that fecal coliform was originating from each of the land uses. As such, staff considered numerous activities associated with all land uses as potential sources.

Staff considered the difficulty of isolating sources, even at small watershed scales using conventional sample analysis methods such as multiple tube fermentation. Additional sample analyses or data collection methods (e.g., genetic study) might provide more information regarding the relative contribution of fecal coliform entering each of the listed water bodies within the Santa Maria and Oso Flaco watersheds from each land use. However, staff concluded that sufficient information is available to determine likely sources to the listed water bodies.

Staff concluded that the following land uses were most likely to contribute to impairment of the listed water bodies, in decreasing order of contribution:

- Rangeland
- Urban/commercial
- Rural residential
- Irrigated agriculture

Table 11 shows which sources are associated with these land uses.

Table 11. Sources of fecal coliform to Santa Maria and Oso Flaco watersheds.

Source	**Land use**
Human waste	Urban; Rural Residential, Irrigated agriculture
Pet waste	Urban; Rural Residential
Cattle and other livestock	Rangeland; Rural Residential
Land-applied non-sterile manure on irrigated lands	Irrigated agriculture
Hydromodification resulting in increased temperatures that may promote bacteriological reproduction	All
Uncontrollable wildlife (including birds)	All

Water Board staff concluded that existing permitted facilities are not documented sources of fecal coliform to the listed water bodies.

The ability to definitively differentiate the origin of the sources from each land use type and from the uncontrollable sources is the chief uncertainty in developing the TMDLs. Furthermore, there is uncertainty regarding the relative contribution of bacterial loading from sources originating from certain land uses, particularly irrigated agriculture and rural residential areas. Continued monitoring of the listed water bodies will indicate whether the allocations from controllable sources are met, thereby minimizing uncertainty about the impacts of loads on water quality.

6. Critical Conditions and Seasonal Variation

Staff determined that there was a pattern of seasonal variation based on review of the exceedance monitoring data. Some sites were more elevated during the dry season and others during the wet season, while others elevated year-round. Critical conditions for this project may include the influence of weather, flow, and temperature conditions, but the extent of the influence on bacteria conditions is uncertain. The critical conditions or seasonal variations, however, did not influence the TMDLs, allocations or implementation and therefore, recommendations for this project apply during all seasons and address the most critical conditions for bacteria concentrations.

7. TMDL Calculation and Allocations

A Total Maximum Daily Load (TMDL) is the loading capacity of a pollutant that a water body can accept while protecting beneficial uses. Usually, TMDLs are expressed as loads (mass of pollutant calculated from concentration multiplied by the volumetric flow rate), but in the case of fecal coliform, it is more logical for the TMDL to be based only on concentration. TMDLs can be expressed in terms of either mass per time, toxicity or other appropriate measure [40 CFR §130.2(I)]. A concentration-based TMDL is logical for this situation because the public health risks associated with recreating in contaminated waters scales with organism concentration, and pathogens are not readily controlled on a mass basis. Therefore, staff proposes establishing a concentration-based TMDL for fecal coliform in the listed water bodies. The TMDL is the same set of concentrations as were proposed in the numeric targets section (Table 12).

Table 12. TMDL for Santa Maria and Oso Flaco water bodies

Fecal Coliform [a]	
Log Mean	Maximum
200 MPN/100 mL [b]	400 MPN/100 mL [c]
E. coli [d]	
Log Mean	Maximum
126 Mean density/100 mL [e]	235 Maximum density /100 mL [f]

a: Source - Regional Water Quality Control Board, Basin Plan 1994.
b Log mean of no less than five samples over a period of 30 days.
c: No more than 10% of total samples during a period of 30 days exceed.
d: Source – U.S. EPA's 1986 bacterial indicator criteria recommendation.
e: Calculated to nearest whole number using equation: geometric mean = antilog_{10} [(risk level + 11.74) / 9.40].
f: Calculated using the following: single sample maximum = geometric mean * 10^(confidence level factor * log standard deviation), where the confidence level factor is: 75%: 0.68; 82%: 0.94; 90%: 1.28; 95%: 1.65. The log standard deviation from EPA's epidemiological studies is 0.4 for fresh waters.

The proposed waste-load and load allocations for all *non-natural* sources are equal to the TMDL concentration and focus on reducing or eliminating the controllable sources of fecal coliform. These sources shall not discharge or release a "load" of bacteria, or fecal coliform, that will increase the load above the loading capacity of the water body. All areas of the tributaries will be held to these allocations.

The allocation to background (including natural sources from birds) is also the receiving water fecal coliform concentration equal to the TMDL. The parties responsible for the allocation to controllable sources are not responsible for the allocation to natural sources.

The TMDL is considered achieved when the allocations assigned to the controllable and natural sources are met, or when the numeric targets are consistently met in all water bodies.

Should all control measures be in place and fecal coliform levels remain high, investigations (e.g., genetic studies to isolate sources, additional monitoring to evaluate influences of channel characteristics) will take place to determine if the high level of fecal coliform is due to uncontrollable sources. Responsible parties may demonstrate that controllable sources of fecal coliform are not contributing to exceedance of water quality objectives in receiving waters. If this is the case, staff may consider re-evaluating the targets and allocations. For example, staff may propose a site-specific objective to be approved by the Water Board. The site-specific objective would be based on evidence that natural, or "background" sources alone were the cause of exceedances of the Basin Plan water quality objective for fecal coliform.

Water Board staff concluded that we should analyze the appropriateness of the beneficial use designations for Blosser and Bradley Channels as these water bodies did not appear to support the water-contact recreation beneficial use identified in the Basin Plan.

8. IMPLEMENTATION ALTERNATIVES

8.1. Introduction

The purpose of a TMDL Implementation Plan (Plan) is to describe the steps necessary to reduce loads and achieve the TMDL. Staff identified implementation alternatives that will likely be included in the Plan. This section includes potential implementation alternatives that staff expects would reduce bacterial loading and the parties that would be responsible for taking these actions. These are discussed below. Also interim actions that could be taken during TMDL development are discussed. The Implementation Plan will ultimately include specific actions and a timeline to achieve the TMDL.

8.2. Alternatives

Water Board staff recognized numerous existing efforts and regulatory mechanisms aimed at reducing bacterial loading. These included, but are not limited to the following: farmers and ranchers implementing irrigated agricultural and grazing management measures, rural landowners maintaining individual sewage disposal systems and implementing management measures to control livestock wastes, and municipalities implementing storm water management measures. Staff identified possible implementation actions or alternatives for all sources (e.g. storm water, agriculture, grazing) that may be contributing to the impairment. Actions that address bacterial reductions from nonpoint sources must be consistent with the Policy for Implementation and Enforcement of the Nonpoint Source Pollution Control Program (SWRCB, 2004). Potential implementation alternatives are described below.

Implementation actions and monitoring requirements are likely to rely on existing and proposed regulatory mechanisms. Staff recommends the following actions be developed or modified as part of TMDL implementation to address fecal coliform loading:

- Review, approve, and enforce implementation of bacterial reduction management measures in Storm Water Management Plans for the City of Santa Maria and the Counties of Santa Barbara and San Luis Obispo;
- Enforce the existing discharge prohibition on individual sewage disposal systems in the most densely populated portions of the community of Nipomo;
- Enforce the existing discharge prohibition to Alamo Creek, and the Santa Maria River downstream from Highway One bridge;
- Implement Nonpoint Source (NPS) control implementation programs (e.g. photo-documenting management measures, presenting Ranch Water Quality Plans developed as part of short-courses) for grazing operations, farm animal and livestock facilities on rural residential land uses, as part of WDRs, waivers, or prohibitions to comply with NPS Policy;
- Develop and implement manure management practices and provision of portable toilets for irrigated agricultural lands; and
- Update wastewater treatment plant permits to include collection system management plans during permit renewal.

8.3. TMDL development recommendations

Staff identified actions that could be taken pro-actively during TMDL development. These are described below. If these actions are not taken prior to TMDL adoption, they may be required through modifications to existing regulatory mechanisms or new regulatory mechanisms. The actions and regulatory mechanisms to require the actions would be included in the Plan.

- The County of San Luis Obispo and/or the Nipomo Community Services District should ensure that 1) all individual sewage disposal systems within the prohibition zone are connected to the sewage treatment plant and 2) that all individual sewage disposal systems outside of the prohibition zone are functioning properly;
- Land owners should ensure that they are in compliance with the waste discharge prohibitions to inland waters: 1) all surface freshwater impoundments and their immediate tributaries (including Alamo Creek), and 2) to the Santa Maria River downstream from Highway One bridge;
- The City of Santa Maria should monitor additional stations as necessary (e.g. in listed channels/water bodies flowing through the City) during storm events and during dry season flows (when present);

- Irrigated agricultural land owners should monitor irrigation return flows from property (possibly through use of the Colilert method by Water Board staff) to determine if property can be excluded from TMDLs and associated follow-up monitoring; and
- Water Board staff will evaluate the possibility of removing the beneficial use designation for water-contact recreation from Blosser and Bradley Channels; based on the evaluation, staff may conduct an analysis of recreational uses in the water bodies and propose removal of inappropriate beneficial uses.

9. PUBLIC PARTICIPATION

The primary goals of stakeholder involvement in the Santa Maria and Oso Flaco watersheds are to learn about existing implementation efforts and available information (e.g. water quality data), to communicate TMDL project status to agency staff and individuals, to coordinate additional data collection, and to gain support for the potential implementation strategies and to develop additional monitoring activities.

The primary framework for stakeholder involvement to date has been email and phone correspondence, staff participation in an existing group's meetings (e.g. a farm water quality short-course) and focused meetings to request specific information (e.g. water quality data) or to answer specific questions (e.g. regarding implementation approaches).

Staff will request review and comments on this report as to whether the data analyses for the TMDL components include all available data and information and support the conclusions drawn, along with input and ideas on implementation strategies.

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